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14. ABSTRACT

As the global campaign against terrorism continues, the contributions of unmanned aircraft systems (UAS) have reached unprecedented levels. Some claim that these assets are essential to the armed forces' ability to conduct modern warfare. Due to these systems' capabilities, combatant commanders are requesting ever-greater numbers of unmanned vehicles. However, the employment of more UAS in the theater of operations comes at a price: there are tremendous challenges associated with unmanned aircraft (UA) sharing airspace with manned assets. There have been at least two recent collisions between unmanned and rotary-wing aircraft at lower altitudes in Iraq, as well as numerous near misses with fixed-wing aircraft at higher altitudes. Existing airspace management problems will be further compounded by introduction of additional assets into congested airspace. The effective integration of unmanned aircraft into the battlespace will only occur with concurrent changes in doctrine, organization, training, and materiel. The synergy created by a blended force of manned and unmanned assets will be of great benefit to the Joint Force Commander (JFC).

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UNMANNED AIRCRAFT SYSTEMS: THE ROAD TO EFFECTIVE INTEGRATION

By

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A paper submitted to the faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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ABSTRACT

As the global campaign against terrorism continues, the contributions of unmanned aircraft systems (UAS) have reached unprecedented levels. Some claim that these assets are essential to the armed forces' ability to conduct modern warfare. Due to these systems' capabilities, combatant commanders are requesting ever-greater numbers of unmanned vehicles. However, the employment of more UAS in the theater of operations comes at a price: there are tremendous challenges associated with unmanned aircraft (UA) sharing airspace with manned assets. There have been at least two recent collisions between unmanned and rotary-wing aircraft at lower altitudes in Iraq, as well as numerous near misses with fixed-wing aircraft at higher altitudes. Existing airspace management problems will be further compounded by introduction of additional assets into congested airspace. The effective integration of unmanned aircraft into the battlespace will only occur with concurrent changes in doctrine, organization, training, and materiel. The synergy created by a blended force of manned and unmanned assets will be of great benefit to the Joint Force Commander (JFC).

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INTRODUCTION

As the global campaign against terrorism continues, the contributions of unmanned aircraft systems (UAS) have reached unprecedented levels.[1] All three military departments currently employ UAS, with some twenty types of unmanned aircraft (UA) having flown over 100,000 hours in support of ongoing operations in Iraq and Afghanistan.[2] Unmanned systems have proven their worth in a vast array of mission areas, including interdiction, force protection, signal collection, reconnaissance, surveillance, and target acquisition (RSTA). According to some reports, these assets are essential to the armed forces' ability to conduct modern warfare.[3] Due to these systems' versatility and persistence, combatant commanders are requesting ever-greater numbers of unmanned vehicles.[4] However, the deployment of more UAS into the theater of operations comes at a price: there are tremendous challenges associated with UA sharing airspace with manned assets. In Iraq, there have been at least two recent collisions between unmanned and rotary-wing aircraft at lower altitudes, as well as numerous near misses with fixed-wing aircraft at higher altitudes.[5] If UAS are to continue to transform the conduct of military operations in the future and play an important role in the Global War on Terrorism (GWOT), it is imperative that they are able to operate in concert with manned assets in the battlespace. Existing airspace management problems will be further compounded by the projected introduction of additional unmanned systems into already congested airspace.[6] This is a complex problem that can only be addressed with a multifaceted solution. The effective integration of unmanned aircraft into the battlespace requires concurrent changes in doctrine, organization, training, and materiel.

This topic is of great concern to the Joint Force Air Component Commander (JFACC), who "synchronizes and integrates" the actions of assigned, attached, and

supporting forces in the airspace to maximize operational effectiveness.[7] Current joint doctrine prescribes that the JFACC also functions as the Airspace Control Authority (ACA). The ACA is responsible for "planning, coordinating and developing airspace control procedures and operating an airspace control system."[8] More specifically, as the airspace manager for the Joint Force Commander (JFC), the ACA governs the use of all airspace by both manned and unmanned aircraft.[9] The value of airpower rests predominantly in its flexibility and its ability to respond quickly across the breadth of the battlespace. The ACA must ensure that all airspace users possess sufficient freedom of action to be responsive to the needs of the JFC.

This work seeks to answer the question, "What steps need to be taken to better integrate manned and unmanned aircraft in the battlespace?" Before answering this query, it is important to mention the limits that were placed on the research conducted for this paper. First, ballistic vehicles, cruise missiles, and artillery projectiles were not considered because they are not classified as UA.[10] Second, this research solely examines the joint integration of manned and unmanned aircraft, and not the separate but related issue of *multinational* integration. With forty-one nations operating approximately eighty different types of UA, interoperability between U.S. systems and those of coalition partners certainly will be a key to successful military operations in the future.[11]

BACKGROUND AND ANALYSIS

Integration is more than just the deconfliction of assets; it is "the arrangement of military forces and their actions to create a force that operates by engaging as a whole."[12] The ACA facilitates this integration through his management of the airspace. Successful management can help increase combat effectiveness by ensuring the safe and efficient use of

airspace. Airspace control procedures can enhance the effectiveness of the assets being controlled by preventing mutual interference, safely accommodating airspace users, and promoting freedom of action.[13]

Interoperability is a critical enabler for integration. The current *Department of Defense Dictionary of Military and Associated Terms* defines interoperability as “the ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together.”[14] Regrettably, UA operations have traditionally been beset by their lack of interoperability. For instance, some customers are not able to access and process the sensor products provided by current unmanned systems.[15] While this issue stems largely from the fact that different services have long pursued separate UAS programs, there are also interoperability issues within the services. As an example, the Army’s RQ-7 Shadow and MQ-5 Hunter UAS are not capable of communicating with each other and cannot be controlled by a single operator.[16] This area of concern is unlikely to be resolved any time soon. Recently, Deputy Defense Secretary Gordon England terminated the Joint Unmanned Combat Air Systems (J-UCAS) program, a program aimed at developing a similar UAS for both the Navy and the Air Force.[17] This decision forces the two services to again pursue independent unmanned aircraft programs, further complicating the notion of fielding fully interoperable systems in the future. Due to interoperability problems such as these, UAS are often seen as “additional assets” instead of an integral part of the force structure.[18]

Limitations of Unmanned Aircraft

Despite the contributions they have made to the nature of modern warfare, unmanned systems are not a panacea. When compared with their manned counterparts, UA are quite

limited in terms of payload capacity, maximum airspeed, adverse weather capability, reliability, and combat survivability. This list is by no means all-inclusive, but it is representative of some of the issues plaguing the current generation of unmanned systems. These shortcomings diminish the operational utility of UAS and reinforce the argument that manned aircraft will not be entirely replaced in the foreseeable future. While it is beyond the scope of this paper to expound fully upon these limitations, the one which probably has the greatest impact on airspace integration is reliability.

Reliability may indeed be the largest impediment to airspace integration.[19] This issue is at the core of the problem of unmanned vehicles achieving routine airspace access and operating in conjunction with manned aircraft. Historically, UA have suffered mishaps at a much greater rate than that incurred by manned military aircraft.[20] While significant progress has been made during the last few years, overall UAS reliability still lags appreciably behind that of manned aircraft.[21] As a result, some pilots may have an aversion to flying around remotely-piloted vehicles, which exacerbates the problem of integration from a cultural standpoint.[22]

There is one other limitation to UAS operations that warrants mention. While pilots "see and avoid" to effect deconfliction, unmanned vehicles do not currently perform a similar "sense and avoid" function. This incapacity is particularly important when one considers the dangers associated with potential communications latencies or failures, when an operator may be temporarily unable to control a vehicle. On more than one occasion, a Predator UA has crashed after the operator's data link was broken.[23]

Airspace Control

Air operations in the Joint Operations Area (JOA) adhere to several governing documents, including the Airspace Control Plan (ACP), the Airspace Control Order (ACO), Special Instructions (SPINS), and the Air Tasking Order (ATO). The ACO is the means used to deconflict, coordinate, and integrate the use of JOA airspace. It provides the details of approved airspace coordinating measures (ACMs), which are "employed to facilitate the efficient use of airspace to accomplish missions and simultaneously provide safeguards for friendly forces."[24] The ACA generally resolves airspace conflicts by providing time or altitude separation, relocating an airspace user, or simply by accepting the risk involved with allowing assets to operate in the same area at the same time.[25] Changes to the ACO are published any time a new area is established or an existing one is deleted. Compiling the ACO can be a very complicated and dynamic process. During the major combat operations phase of Operation Iraqi Freedom (OIF), approximately 1,800 ACMs were required to build the ACO, and it was changed an average of twelve times per day.[26] Due to the ACO's evolving nature, persistent communications are necessary to disseminate last minute changes to airspace users.

There are two primary methods of airspace control, procedural control and positive control. The ACA applies an appropriate combination of procedural and positive control to manage assets in the airspace. Procedural control relies on *previously promulgated* orders and ACMs, such as specific routes, coordinating altitudes, and operating zones for airspace users.[27] The Army prefers the use of procedural control measures for its air operations. Procedural control is consistent with the Army's guiding philosophy of "centralized planning, *decentralized control*, and decentralized execution."

In contrast to procedural control, positive control electronically identifies, tracks, and directs assets in *real time* using radar, transponders, data links, and other sensors. Continuous communications with airspace users are required to exercise positive control. The Air Force predominantly employs this type of control, which is in keeping with its tenet of "centralized planning, *centralized control*, and decentralized execution." Positive control may be more appropriate than procedural control in a dynamic combat environment because of its real-time nature. Yet, positive control requires a more robust command and control (C2) infrastructure than procedural control due to its intensive communications requirements.

Some unmanned vehicles lack the requisite systems to be positively controlled. For example, not all UAS have transponders or the ability to directly communicate with other airspace users. Such deficiencies make it difficult for these UA to operate in close proximity to manned aircraft. Consequently, current airspace control doctrine prescribes that UA are typically *segregated* from manned assets. This segregation can be accomplished in a number of ways. The standard means of providing separation is to assign unmanned vehicles to operate within restricted operations zones (ROZs). A ROZ is a block of airspace with defined lateral boundaries and altitudes that is promulgated in the ACO. When possible, manned systems remain clear of UA ROZs. An aircraft needing to penetrate a ROZ to accomplish its mission flies under see-and-avoid principles and accepts the risk involved. As most UA are relatively slow and small, they may be difficult to see or to track by an aircraft operating within the ROZ. An additional drawback to using ROZs is that they essentially "block off" airspace, which may be a precious commodity in a crowded JOA.

Another way to reduce potential conflicts between unmanned and manned systems is with a UAS blanket altitude. A UAS blanket altitude is a particular altitude reserved

exclusively for UA, or a designated altitude where manned aircraft will not operate. While ACMs such as UA ROZs and blanket altitudes help provide the safest possible battlespace, they also limit freedom of movement for other airspace users, which may delay response time or reduce mission effectiveness. Routine reliance on the segregation provided by ACMs such as these acknowledges the difficulty in integrating UAS into the existing airspace structure.

Unmanned Aircraft and the ATO

There are times when manned and unmanned aircraft must share the same airspace. A scenario that is becoming increasingly common is a fixed-wing platform delivering ordnance on a target being illuminated by a UA. As is illustrated by the collisions and near misses that have already occurred, there is a certain level of risk associated with using the existing means of deconfliction. Air Force doctrine asserts, "If UAV operations are not deconflicted properly, unsafe flying conditions may result, which may result in some airspace users being unable to accomplish their mission."[28] When called upon to support troops on the ground, it is conceivable that a manned aircraft could be unduly delayed until the airspace is cleared of conflicting UA so as to allow the manned aircraft "to maneuver in a relatively uncluttered and less restrictive environment."[29]

The procedural control method that has traditionally been used to deconflict fixed-wing and rotary-wing aircraft is known as a *coordinating altitude* (CA). Fixed-wing aircraft fly above the CA and are controlled by the ACA; helicopters operate below it and are managed by the Army. The CA is normally specified in the ACP, and has been set at 3,000 feet for recent combat operations.[30] While this ACM has worked satisfactorily in the past, the proliferation of UAS poses a significant challenge to this scheme of airspace

management. There are more than 1,000 UA operating in Iraq and Afghanistan today, and the majority of these fly below the CA and share airspace with rotary-wing aircraft.[31]

Since the JFACC may not own all of the assets operating in the airspace, coordination is vital for effective integration. The ATO is one method to effect this coordination. Joint doctrine states that "all air missions, including both fixed- and rotary-wing of all components, should appear on the appropriate ATO or flight plan…."[32] Joint C2 doctrine follows suit, noting that even a component commander's "organic assets should appear on the ATO to enable coordination and minimize the risk of fratricide."[33] Even so, in current operations, aircraft operating below the CA and inside the fire support coordination line (FSCL), both manned and unmanned, are *not* included on the ATO.[34] Smaller unmanned vehicles such as the Army's Raven are unlikely to appear on the ATO as well.[35] Yet, even small UA are capable of operating at altitudes that can make them a hazard to helicopters or low-flying fixed-wing assets.[36] Airspace coordination and deconfliction are needlessly complicated when some UA are absent from the ATO.

UAS Oversight

Under the auspices of the Department of Defense (DOD), a number of agencies have been formed to help with UAS oversight and to encourage interoperability. The UAS Planning Task Force (formerly called the Joint UAV Planning Task Force) was established by the Office of the Secretary of Defense (OSD) in 2001. The UAS Planning Task Force aspires to "promote common vision and establish interoperability standards" for UAS, but it has been criticized for its lack of directive authority.[37] The U.S. Joint Forces Command (USJFCOM), in conjunction with the U.S. Strategic Command (USSTRATCOM), has been tasked with developing unmanned and manned aircraft tactics, techniques, and procedures

(TTPs).[38] In particular, USJFCOM is working to develop doctrine to better integrate UAS into the current force structure. If successful, this endeavor will go a long way in helping to overcome some of the integration problems described here. Another activity, the Joint Unmanned Aircraft Systems Material Review Board (formerly the Joint Unmanned Aerial Vehicle Overarching Integrated Process Team), is helping services manage the development of new and the modification of existing UAS to improve interoperability.[39] Recently, the Joint UAV Center of Excellence (COE) was established at Creech Air Force Base in Nevada. This Joint COE is "an operationally focused organization concentrating on UAV systems technology, joint concepts, training, tactics, and procedural solutions to the warfighters' needs."[40] Finally, service-centric bodies are also overseeing various aspects of UAS integration, such as the Army's own UAV COE, the Air Force's UAV Battlelab, and the Navy's Joint UAV Tactical Development and Evaluation Office. To be sure, this mix of organizations with seemingly overlapping functions and purviews is a bit confusing. All these agencies appear to be pursuing similar goals with respect to UAS integration, joint interoperability, and associated doctrine development. Nevertheless, the degree to which their efforts are being coordinated is not readily apparent.

RECOMMENDATIONS

It is clear that steps must be taken to effectively integrate UA with manned assets in the battlespace. UAS cannot solely be isolated from manned assets. This is restrictive, and is not true integration. Instead, unmanned vehicles must be able to function with other aircraft synergistically. The goal is to "enable combat operations without undue restrictions, balancing combat effectiveness with the safe, orderly, and expeditious use of airspace."[41]

The following recommendations seek to meet this end, and are divided into four categories: doctrine, organization, training, and materiel.

Doctrine

The first area which requires attention is doctrine development. There is remarkably little formal doctrine that explicitly pertains to UAS. Airspace management doctrine must be revised with unmanned systems in mind, beginning with Joint Publication 3-52, *Joint Doctrine for Airspace Control in the Combat Zone*. The current text offers very cursory guidance, leaving detailed development of UAS-specific ACMs to the ACA. Just one paragraph is devoted to unmanned vehicles, relying on the precept that "the established principles of airspace management used in manned flight operations will normally apply to UAV operations."[42] As previously illustrated, not only are there pronounced differences between manned and unmanned aircraft, but even these established principles are at times contradictory. Unquestionably, this publication needs to address unmanned operations in greater detail.

It is critical that all UAS are fully integrated into the ATO and adhere to the ACO. This step is not only necessary for deconfliction, but also to prevent fratricide. One may argue that placing all UA on the ATO is constraining to subordinate commanders. Joint Publication 3-30 confirms that this is not the case: "The inclusion of component air assets in the ATO does not imply any command or tasking authority over them, nor does it restrict component commanders' flexibility to respond to battlespace dynamics."[43]

To best preserve freedom of movement for manned aircraft, the ACA should strive to limit the number of UA ROZs in the ACO. Moreover, the number of UAS populating the battlespace must be kept to a reasonable level to prevent overcrowding. That is, the total

number of platforms occupying the airspace must be commensurate with the size of the airspace. More unmanned systems in the battlespace does not necessarily equate to increased mission effectiveness if freedom of action is being restricted and safety is being compromised. As UA are added, perhaps manned platforms need to be removed. Joint experimentation can help determine what the proper density of assets should be. Tests should also be conducted to verify that 3,000 feet is indeed the best place for the CA. Raising the CA would undoubtedly reduce UA congestion at altitudes where deconfliction challenges are the greatest. On the other hand, raising the CA might also adversely affect the operations of fixed-wing aircraft by limiting their access to lower altitudes.

Joint doctrine can reduce confusion by describing common, accepted procedures. The only UAS-specific doctrine, 1993's Joint Publication 3-55.1, *Unmanned Aerial Vehicles Tactics, Techniques, and Procedures*, was recently rescinded because service planners decided that "UAV doctrine should be disseminated in mission-oriented publications, rather than those focused on UAVs."[44] Unfortunately, UAS doctrine is not sufficiently covered anywhere else. Thus, this action leaves a gap for those airspace users not accustomed to working with UA. The question remains whether specific UAS considerations will actually be included in future revisions of mission-specific joint publications, or whether UAS will merely continue to be categorized as manned aircraft with no regard for their unique characteristics.

Organization

Changes in technology often necessitate changes in organizational structures. While UAS may be more evolutionary than revolutionary, their recent proliferation has uncovered a seam in existing C2 constructs. Effectual C2 helps ensure unity of effort for the benefit of

the joint force as a whole. If the tenet of centralized control were universally accepted, there would be a single commander directing air operations throughout the JOA. This would better ensure functional integration and assuage airspace management challenges. Continued progress must be made the field of joint airspace control, encompassing all manned and unmanned assets. Tactical level C2 simply complicates integration.

DOD has established no fewer than five different organizations to promote UAS interoperability.[45] In this case, the number of different agencies simply makes it more difficult to coordinate efforts and ensure that a common course is being pursued. The functions of these organizations must be clarified and their efforts better synchronized to discourage redundant efforts and to foster interoperability across the services. For example, the relationship between USJFCOM and the newly-established Joint UAV COE is unclear with respect to doctrine development. USJFCOM has statutory responsibility for developing future concepts for joint warfighting.[46] Due to this mandate, it seems logical that USJFCOM should also assume the leading role in developing all UAS TTPs and doctrine.

In its 2004 report on unmanned aircraft, the Defense Science Board proposed the creation of a [Joint] Deployable UAV Operations Cell to aid the JFACC with planning considerations.[47] While only a few words are devoted to this concept in the report, the idea has merit. Composed of representatives from activities that operate unmanned platforms, this cell could help to better integrate and synchronize UA activities in the theater of operations. The officer in charge of the cell would supervise its activities, as well as serve as a central point of contact for all unmanned operations in the battlespace. This cell could also help units owning UA that are unaccustomed to the ATO process become familiar with its function.

Training

Two specific changes with regard to training both aircrew and UAS operators would also support integration. First, UAS must be integrated into joint exercises and joint training to the maximum extent possible. Today, these assets are infrequent participants in realistic joint exercises such as Red Flag and Joint Task Force Exercise (JTFEX) due to high operational tempo (OPTEMPO) and a subsequent lack of available vehicles and funding.[48] As a result, aircrew may be largely ignorant of the true capabilities and limitations of UAS. Realistic training with unmanned platforms would better familiarize aircrew with UA capabilities, as well as help establish linkages between units to promote teamwork. Such training may also alleviate some of the adverse feelings aircrew might have about sharing the battlespace with unmanned vehicles.

Second, there are currently no universal standards of training for UAS operators. Each service creates its own training programs to prepare its unmanned fleet operators. With the exception of the Army's Hunter and Shadow UAS programs, "each UAS has a dedicated training program, underscoring the lack of interoperability among these systems in the field."[49] Depending on the service and the type of unmanned vehicle, the operator may not even be a rated pilot. Since the majority of unmanned vehicles operate at altitudes where they may come into contact with manned platforms, *all* UA operators should meet Federal Aviation Administration (FAA) qualification standards. These operators must be capable of responding to air controllers' commands, regardless of whether the vehicle is operating in the national airspace system or in the combat zone.

Materiel

DOD has acknowledged that by trying to meet increasing demands for UAS, assets have been deployed as quickly as possible, without regard to needed performance baselines.[50] A common belief has been that the best path to integration is to treat UA like manned platforms, and the *Joint Publications* support this point of view by treating UA identically to manned aircraft with respect to airspace control procedures. However, in order to be regarded like their manned counterparts, UA must be able to operate under the same air traffic control standards as manned aircraft. Whether or not an aircraft is manned should be transparent to both controllers and other airspace users. Unfortunately, many UAS do not have the requisite capabilities to integrate safely and efficiently into the battlespace today.[51] They are not "plug and play" assets. Although materiel solutions are often costly, several issues must be addressed to permit effective integration.

First, the different services' efforts should be coordinated and non-duplicative in order to boost interoperability and standardization. In keeping with traditional acquisition practices, each service has developed UAS to meet service-specific requirements with little regard for integrating capabilities on the joint level. This has led to redundant efforts by the different military departments. While the J-UCAS was a major step forward, its recent cancellation is two steps back. If given the opportunity, services will continue to develop systems to their own standards and with little regard for others' standards. This "reluctance of one military system to use the UAV system of another" compounds interoperability problems.[52] An acquisition strategy emphasizing inter-service collaboration is needed to ensure interoperability among UAS. The future lies in jointly-developed systems, not service-specific ones. Even if joint systems are not developed, military services should still

be encouraged to procure the systems of another service whenever possible to improve interoperability and reduce needless expenditures.[53]

Next, unmanned vehicles must be equipped with systems that will facilitate their operations in shared airspace, such as transponders and radios for direct communications. Not all UAS in service currently have these basic systems. While it would be ideal if all UAS could be positively controlled, this may not be feasible. Given the low altitudes at which many UAS operate, environmental and equipment factors may preclude radar control. Still, there is great benefit to be gained by UA having the ability to communicate directly with other airspace users, and transponders could help manned platforms identify friendly UA. Without these essential systems, unmanned vehicles should not be allowed to fly in close proximity to manned aircraft.

Link-16, or tactical digital information links (TADIL J), is analogous in functionality to the blue force trackers used by ground units, with all users providing and having access to reliable positioning information. Link-16 supports airspace control by helping the JFACC see where every aircraft is and where it is planning to go. In this sense, it provides a better "vertical" flow of information. Link-16 also assists the "horizontal" flow of information, allowing platforms to exchange critical targeting and threat information. In short, the system greatly simplifies airspace management by providing real-time battlespace awareness to controllers and users alike. An immediate priority must be to equip every airspace user with Link-16. If every UA were equipped with TADIL J, manned aircraft could be readily deconflicted using positive control.

Continuing to make strides in the area of UAS reliability will help ensure their operational utility in the future. According to an OSD study, reliability is "inextricably tied"

to resources spent.[54] Hence, appropriate funding is necessary to make appreciable gains. The Air Force's Predator program is representative of the improvements that can be made when ample resources are applied to improving reliability. Through 2002, the Air Force had lost 25 of 80 Predators built; however, by 2003, the Predator boasted a loss rate that was "below the level of some manned aircraft."[55]

Finally, the automation of sense-and-avoid has been cited as the key technical hurdle precluding UA from operating alongside manned aircraft.[56] A dependable UA collision avoidance system would better permit unmanned and manned aircraft to fly in the same airspace. While an automatic sense-and-avoid collision system has been shown to be feasible by the Air Force in preliminary testing, no automatic collision avoidance systems are currently being utilized on UAS.[57] Adequate resources should be directed to accelerating research in this area, leveraging the FAA's Traffic Alert/Collision Avoidance System (TCAS) currently installed in commercial aircraft.

CONCLUSION

The capabilities of UAS are vital to the JFC today, and UAS will undoubtedly continue to excel in the proverbial "dull, dirty, and dangerous" missions in the future. UAS operations are no longer considered extraordinary; they have become routine. While not making the headlines, MQ-1 Predators are being used to monitor insurgent activities and to attack targets in Iraq and Afghanistan with certain regularity.[58] With the DOD planning to invest over $11 billion on UAS by 2010, greater numbers of UAS will be fielded by all military services in the near term.[59] These systems will continue to play a significant role in the GWOT, taking part in actions spanning the entire range of military operations. Still, only by operating in conjunction with manned aircraft will the full potential of these systems be

realized. The right "mix of manned and unmanned platforms [will] ensure cost-effective delivery of air power right across the spectrum of conflict."[60] Harmonious operations between unmanned and manned aircraft will allow the JFC to better capitalize on respective strengths while simultaneously mitigating weaknesses. Effective integration will maximize combat effectiveness without inhibiting airspace users.

The road to UAS integration is not an easy one to navigate. A concerted effort must be made to move forward with UAS integration in the battlespace. Only through concurrent changes in doctrine, organization, training, and materiel will successful integration be possible. The ultimate goal is a fleet of unmanned vehicles that are fully capable of operating in conjunction with manned aircraft without added risk. Quite simply, if a new course is not taken, both manned and unmanned operations will become more restrained in the future. Continuing to insert greater numbers of UAS into the airspace structure without due regard for interoperability with manned aircraft is a recipe for failure. Yes, collisions may become more frequent; but even worse, the JFC may not have responsive air assets to answer the call when they are needed the most.

NOTES

[1] UAS has recently emerged as most accepted acronym to describe an entire system that includes aircraft, control stations, and data links. This change reflects the fact that the aircraft is only one component of the system. This acronym is now replacing unmanned aerial vehicle (UAV) in all Department of Defense documents. UAV is used in this paper when it appears in source documents.

[2] Otto Kreisher, "In Demand," *Sea Power 48*, no. 11, (November 2005): 10, ProQuest [22 December 2005]; and Joshua Kucera, "UAV Missions in Iraq Set to Rise," *Jane's Defence Weekly* (19 January 2005), Lkd. <http://search.janes.com> [19 December 2005].

[3] General Accounting Office, *Unmanned Aerial Vehicles: Major Management Issues Facing DOD's Development and Fielding Efforts*, GAO-04-530T (Washington, DC: 17 March 2005), 3, <http://www.gao.gov/new.items/d04530t.pdf> [12 December 2005].

[4] Ibid.

[5] Geoff Fein, "Air Space Deconfliction Remains an Issue for UAV Use, General Says," *Helicopter News* 31, no. 22 (1 November 2005): 1, ProQuest [5 December 2005].

[6] Substantial increases in funding of UA programs during the last few years illustrate the emphasis DOD is placing on UAS. During the 1990s, the DOD invested $3 billion in UAS development, procurement, and operations. In contrast, almost $2.2 billion was spent on UAS in fiscal year 2005 alone. The military services' inventory of UAS is projected to nearly triple by 2010. Office of the Secretary of Defense, *Unmanned Aircraft Systems Roadmap 2005-2030* (Washington, DC: August 2005), 37, <http://www.acq.osd.mil/usd/Roadmap%20Final2.pdf> [14 December 2005].

[7] Joint Chiefs of Staff, *Joint Publication 3-30: Command and Control for Joint Air Operations* (Washington, DC: 5 June 2003), vii.

[8] Ibid., ix.

[9] It is important to note that no real distinction is made between manned and unmanned aircraft in either *Joint Publication 3-30* or *Joint Publication 3-52*. *Joint Publication 3-52* devotes only a single paragraph to unmanned vehicle considerations.

[10] Joint Chiefs of Staff, *Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms* (Washington, DC: 31 August 2005), 563.

[11] Office of the Secretary of Defense, *Unmanned Aircraft Systems Roadmap*, 38. For more information on multinational standardization and interoperability, see Joint Chiefs of Staff, *Joint Publication 3-16: Joint Doctrine for Multinational Operations* (Washington, DC: 5 April 2000), I-10-12.

[12] Joint Chiefs of Staff, *Joint Publication 1-02*, 266.

[13] Joint Chiefs of Staff, *Joint Publication 3-30,* II-4.

[14] Joint Chiefs of Staff, *Joint Publication 1-02*, 274.

[15] Office of the Secretary of Defense, *Unmanned Aircraft Systems Roadmap*, 45.

[16] "Operator" is the generic term used to describe the individual controlling the UA. This individual is trained by the parent service and is responsible for the air vehicle's operations and safety. Government Accountability Office, *Unmanned Aircraft Systems: DOD Needs to More Effectively Promote Interoperability*

and Improve Performance Assessments, GAO-06-49T (Washington DC: December 2005), 10, <http://www.gao.gov/new.items/d0649.pdf> [22 December 2005].

[17] "Pentagon Sets Plan for New Air Force Bomber, Terminates J-UCAS Program," *InsideDefense.com* (12 January 2006), Lkd. <http://insidedefense.com> [14 January 2006].

[18] Office of the Secretary of Defense, *Defense Science Board Study on Unmanned Aerial Vehicles and Uninhabited Combat Aerial Vehicles* (Washington, DC: February 2004), iv.

[19] Office of the Secretary of Defense, *Airspace Integration Plan for Unmanned Aviation* (Washington, DC: November 2004), 31.

[20] Systems failures are the major cause of UA mishaps, with propulsion and flight control issues historically accounting for 80 percent of reliability failures. Office of the Secretary of Defense, *Unmanned Aerial Vehicle Reliability Study* (Washington, DC: February 2003), 29.

[21] The UAS mishap rate has historically been one to two orders of magnitude higher than that of manned military aircraft. Office of the Secretary of Defense, *Unmanned Aircraft Systems Roadmap*, F-2.

[22] Brendan P. Rivers, "The Robot's Got Your Back," *The Journal of Electronic Defense* (January 2003): 50, 53.

[23] David A. Fulghum, "The War at Home," *Aviation Week & Space Technology* 163, no. 12 (26 September 2005): 58, ProQuest [28 November 2005]; and "Operator Error Cited in Predator Crash." *Defense Daily* 209, no. 23 (5 February 2001): 1, ProQuest [28 November 2005].

[24] Joint Chiefs of Staff, *Joint Publication 3-52* (Washington, DC: 30 August 2004), GL-5.

[25] Air Land Sea Application Center, *Multiservice Procedures for Integrated Combat Airspace Command and Control (ICAC2)* (Langley AFB, VA: June 2000), II-5.

[26] Alexander M. Wathen, "The Miracle of Operation Iraqi Freedom Airspace Management," *Air & Space Power Chronicles – Chronicles Online Journal* (4 October 2005), <http://www.airpower.maxwell.af.mil/airchronicles/cc/wathen.html> [22 December 2005].

[27] Joint Chiefs of Staff, *Joint Publication 3-30*, II-4-II-5.

[28] Headquarters Air Force Doctrine Center, *Air Force Doctrine Document 2-1.7: Airspace Control in the Combat Zone* (Maxwell AFB, AL: 13 July 2005), 27.

[29] Headquarters Air Force Doctrine Center, "Doctrine Watch, December 2005: Unmanned Aircraft (UA) and Airspace Control in the Combat Zone," 17 January 2006, Lkd. Air Force Doctrine Center Website, <https://www.doctrine.af.mil> [20 January 2006].

[30] Ibid.

[31] Fein, 1; and Marc V. Schanz, "A Complex and Changing Air War," *Air Force Magazine* 89, no. 1 (January 2006), <http://www.afa.org/magazine/jan2006/0106airwar.html> [18 January 2006].

[32] Joint Chiefs of Staff, *Joint Publication 3-52*, IV-3.

[33] Joint Chiefs of Staff, *Joint Publication 3-30*, II-1.

[34] Headquarters Air Force Doctrine Center, "Doctrine Watch."

[35] Ann Roosevelt, "160th SOAR Wants UAV Capability for Resupply, ISR," *Helicopter News* 31, no. 10 (17 May 2005): 1, ProQuest [22 December 2005].

[36] Section 2 of the *Roadmap* provides performance characteristics for all UAS currently in development and production. Figure F-3 also depicts approximate operating altitudes. Office of the Secretary of Defense, *Unmanned Aircraft Systems Roadmap*, 2-30, F-4.

[37] General Accounting Office, *Major Management Issues*, 2.

[38] Office of the Secretary of Defense, *Defense Science Board Study*, xiii.

[39] Government Accountability Office, *DOD Needs to Promote Interoperability*, 17.

[40] "Joint UAV Center of Excellence at Creech," 11 July 2005, Lkd. Air Force Link Website, <http://www.af.mil/news/story.asp?storyID=123011008> [30 January 2006].

[41] Joint Chiefs of Staff, *Joint Publication 3-30*, III-24.

[42] Joint Chiefs of Staff, *Joint Publication 3-52*, III-6.

[43] Joint Chiefs of Staff, *Joint Publication 3-30*, II-1.

[44] Russell Knight and Keith Allford, "UAVs Need a Better Road Map," *U.S. Naval Institute Proceedings* 130, no. 1 (January 2004): 77, ProQuest [22 December 2005].

[45] Government Accountability Office, *DOD Needs to Promote Interoperability*, 18.

[46] Department of Defense, *Unmanned Aircraft Systems Roadmap*, 66.

[47] Office of the Secretary of Defense, *Defense Science Board Study*, 35.

[48] Some UAS, such as Predator, are now considered high-demand, low-density (HD/LD) assets. William B. Scott, "New Threats, New Tactics," *Aviation Week & Space Technology* 163, no. 17 (31 October 2005): 46, ProQuest [22 December 2005].

[49] Department of Defense, *Unmanned Aircraft Systems Roadmap*, 63.

[50] Government Accountability Office, *DOD Needs to Promote Interoperability*, 5.

[51] William H. Johnson, "UAV 101," *U.S. Naval Institute Proceedings* 127, no. 11 (November 2001): 91-93, ProQuest [2 December 2005].

[52] Office of the Secretary of Defense, *Defense Science Board Study*, 6.

[53] Ibid., v.

[54] Office of the Secretary of Defense, *Reliability Study*, 41.

[55] James R. Asker, "Rumsfeld's Rules," *Aviation Week & Space Technology* 157, no. 11 (9 September 2002): 29, ProQuest [1 February 2006]; and Jefferson Morris, "DOD Preparing Next UAV Roadmap for Release Late This Year," *Aerospace Daily & Defense Report* 210, no. 45 (3 June 2004): 1, ProQuest [1 February 2006].

[56] B. C. Kessner, "UAV Sense-And-Avoid Technologies Not Just a Military Concern," *Defense Daily* 227, no. 22 (2 August 2005): 1, ProQuest [19 December 2005].

[57] Guy Norris, "ACAS for Combat Aircraft is Feasible, Insists USAF," *Flight International* 166, no. 4953 (28 September – 4 October 2004): 25, ProQuest [22 December 2005]; and Donald E. Swihart and others, "Integration Techniques for Preventing Collisions Between Air Vehicles," Conference Paper Preprint, Air Force Research Laboratory, December 2002, 4.

[58] Robert Burns, "U.S. Airpower Strikes Iraq Targets Daily," Washingtonpost.com, 20 December 2005, <http://ebird.afis.mil/ebfiles/e200512200408136.html> [20 December 2005].

[59] General Accounting Office, *Major Management Issues*, 17.

[60] Brian Burridge, "Post-Modern Warfighting with Unmanned Vehicle Systems: Esoteric Chimera or Essential Capability?" *RUSI Journal* 150, no. 5 (October 2005): 20-23, ProQuest [22 December 2005].

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